AERMOD Modeling System Update

Roger W. Brode
U.S. EPA/OAQPS
Air Quality Modeling Group

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Outline

- Recent AERMOD modeling system developments
  - AERMOD dispersion model
  - AERMET meteorological preprocessor
- Evaluation of BETA options in AERMET and AERMOD
- Other developments
  - Upper Air data substitution tool
  - AERSURFACE and Gust Factor Tool
  - Building downwash issues (e.g., elongated buildings)

Issues with v14134 Update

- AERMOD v14134 issues:
  - Optimizations based on relative source/receptor locations has introduced a problem with collocated sources/receptors:
    - Individual hourly results may show up as Infinity or NaN (not a number), and cumulative results may be erroneous;
    - A “QSUM = 0.0” error message may also be issued if PVMRM option is used.
  - A similar problem (Infinity or NaN) also occurs for AREA and OPENPIT sources with the FASTALL and FASTAREA options.

Issues with v14134 Update

- AERMOD v14134 issues (cont):
  - AERMOD incorrectly indicates full conversion for NO2 if ARM option is specified with DFAULT option:
    - However, model results do correctly reflect ARM;
  - AERMOD User's Guide Addendum (Section 2.5) incorrectly states that background concentrations will automatically be included with source group ALL:
    - User must specify BACKGRND on the SRCGROUP ALL keyword to include background concentrations;
    - This issue also applied to v13350; AERMOD automatically issues warning message indicating whether BACKGRND is included for group ALL when the BACKGRND option is used.

Issues with v14134 Update

- AERMOD v14134 issues (cont):
  - A few issues with PVMRM have been addressed (e.g., accounting for plume heights when determining NOx moles), and some aspects of how AREA sources are handled under PVMRM are being reviewed;

Issues with v14134 Update

- AERMET v14134 issues:
  - An application using the ADJ_U* Beta option in AERMET together with the BULKRN (delta-T) option produced questionable results:
    - Unusually high concentrations occurred associated with anomalously large lapse rates (exceeding 1 K/m);
    - This anomaly was similar to an issue that occurred with v12345 using the ADJ_U* option without BULKRN that was apparently corrected in v13350;
    - This prompted a more thorough review of the ADJ_U* and BULKRN options in AERMET and potential inconsistencies with the meteorological profiling within AERMOD.

Issues with v14134 Update

- AERMET v14134 issues (cont.):
  - Incorporation of more refined method in AERMET and AERMOD for estimating theta-star (θ*), based on a 2009 Luhar and Raynor paper (BLM v132), resolved the anomalous results for ADJ_U* with BULKRN;
  - The “bug fix” incorporated in AERMET v13350 to address a similar issue for the original ADJ_U* option (based on linear extrapolation of u*, θ*, and L for WS below “ucrit”) was reassessed since original Qian and Venkatram formulation for ADJ_U* has real solutions for all wind speeds, i.e., no SQRT(negative number).

Issues with v14134 Update

- AERMET v14134 issues (cont.):
  - Incorporating Luhar and Raynor's (2009) more refined method for estimating θ* in AERMET and AERMOD also appears to resolve the anomalous results for the original ADJ_U* option without BULKRN;
  - This reassessment of ADJ_U* options in AERMET and associated changes in AERMOD is still underway (with participation from ORD), including evaluations of overall model performance as compared to original options.

Evaluation of Beta Options

- Continue to update and expand evaluations of Beta options in AERMET and AERMOD;
- Two tracer field studies conducted in the 1974 by NOAA focused on dispersion of low-level releases under low-wind/stable conditions:
  - Oak Ridge, TN, included low-level and elevated releases with sampling arcs at 100m, 200m, and 400m, and wind speeds ranging from 0.15 to 0.73m/s (10 of 11 cases < 0.5m/s);
  - Idaho Falls, ID, included low-level releases with sampling arcs at 100m, 200m, and 400m, and wind speeds ranging from 0.75 to 1.93m/s (4 of 11 cases < 1.0m/s);
  - v12345 results for Idaho Falls and Oak Ridge field studies are summarized in Appendix F of the AERMOD User's Guide Addendum.

Evaluation Caveats

- The preliminary model evaluation results presented here are still under review and are subject to change;
- In addition, several caveats regarding model evaluation should be kept in mind:
  - Evaluating performance of dispersion models is a complex endeavor and results may be affected by errors or uncertainties regarding the correct model inputs, including emission rates, source characteristics, surface characteristics and meteorological data;
  - Errors or uncertainties regarding the interpretation of “observed” concentrations may also significantly affect the conclusions regarding model performance;
  - The potential impact of these caveats on conclusion regarding model performance are likely to be exaggerated in cases with very low wind speeds since results may be highly sensitive to relative small “errors” in important inputs or assumptions.

Evaluation Caveats (cont.)

- Regarding the model evaluation results presented below, the following issues should be noted:
  - EPA's evaluations for Oak Ridge and Idaho Falls deviated in some respects from the original evaluations conducted by AECOM/API:
    - EPA assumed a surface roughness of 0.6m for Oak Ridge as compared to 0.2m assumed by AECOM;
    - EPA assumed a wind measurement height of 10m for Oak Ridge (due to the fact that the observed wind speeds were derived from laser anemometry from lasers sited on the top on nearby ridges, as compared 2m assumed by AECOM;
    - EPA assumed a surface roughness of 0.08m for Idaho Falls, as compared to AECOM's assumption of 0.15m for February and 0.3m for other months (the study spanned from Feb. to May);
    - EPA assumed a release height of 3m for Idaho Falls, based on information presented in the NOAA Technical Memorandum and as assumed by other researchers, as compared to a 1.5m release height assumed by AECOM.

Oak Ridge Study Area

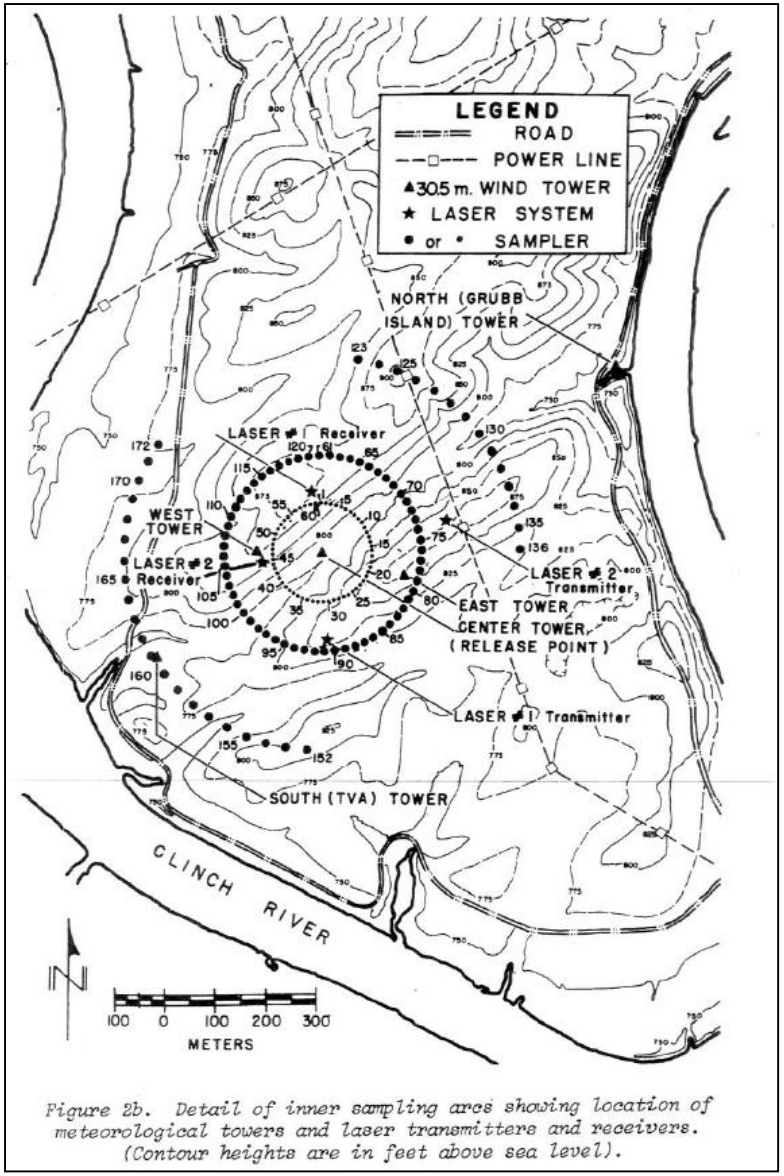
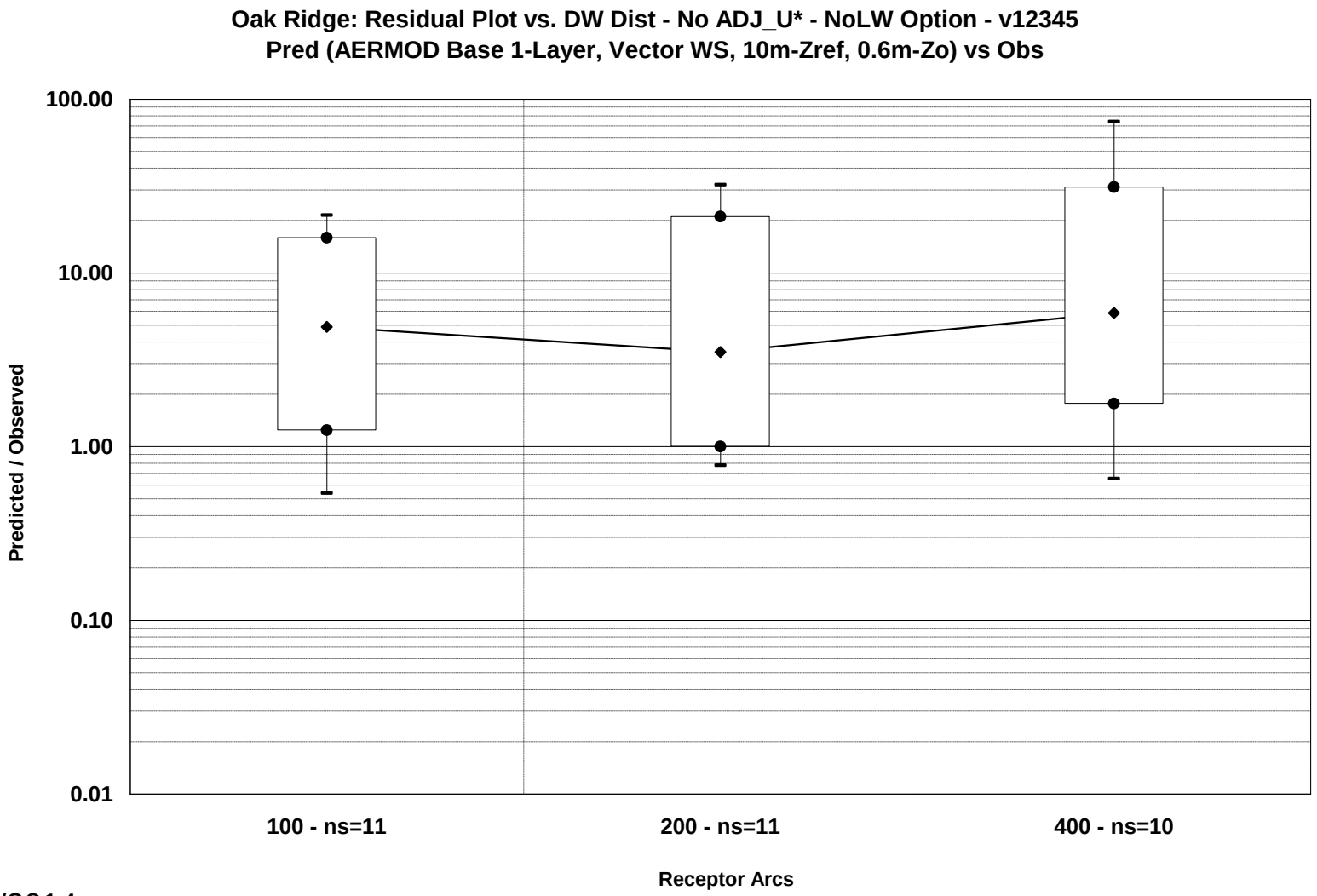


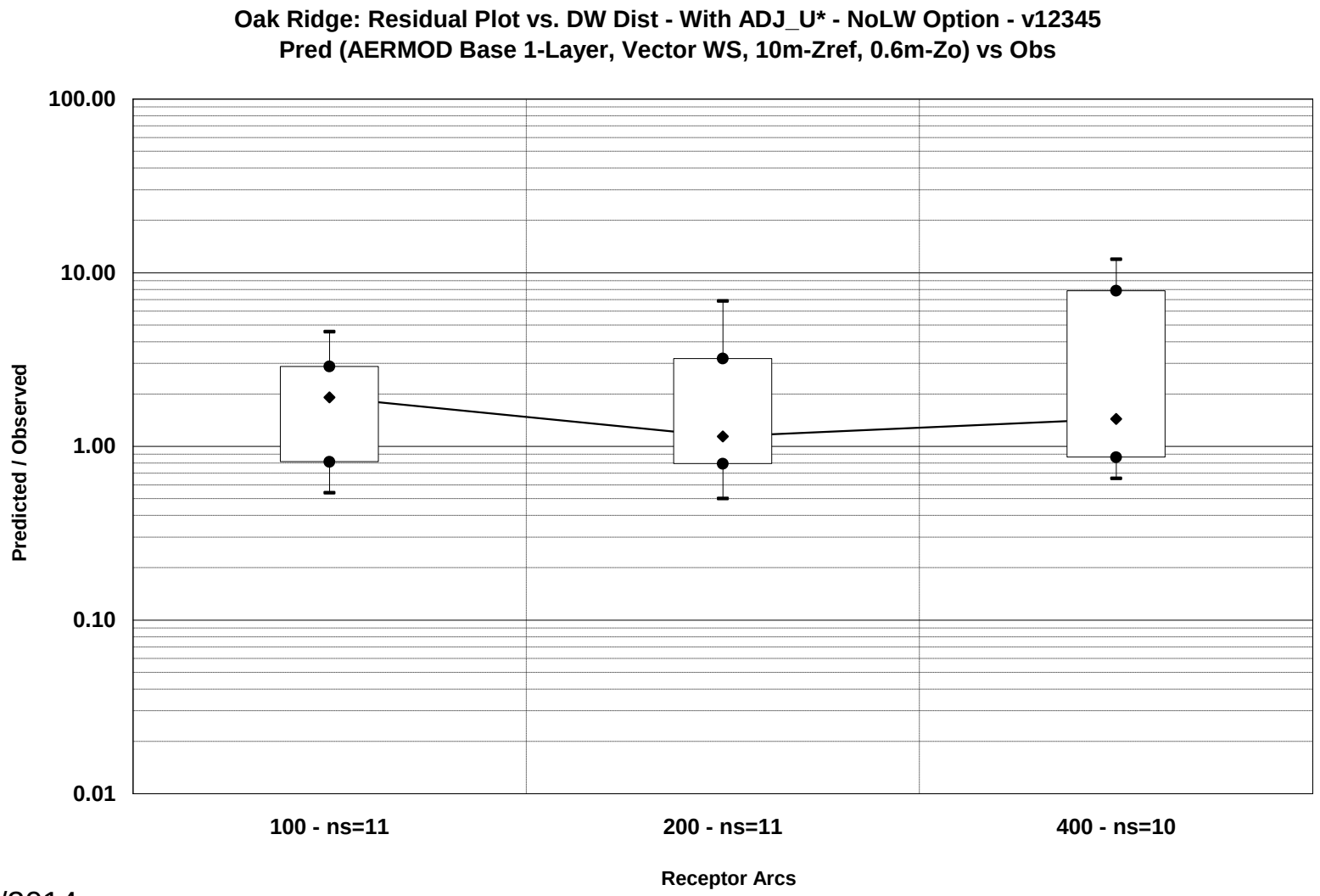
Figure 2b. Detail of inner sampling arcs showing location of meteorological towers and laser transmitters and receivers. (Contour heights are in feet above sea level).

From NOAA Technical Memorandum ERL ARL-61, 1976.

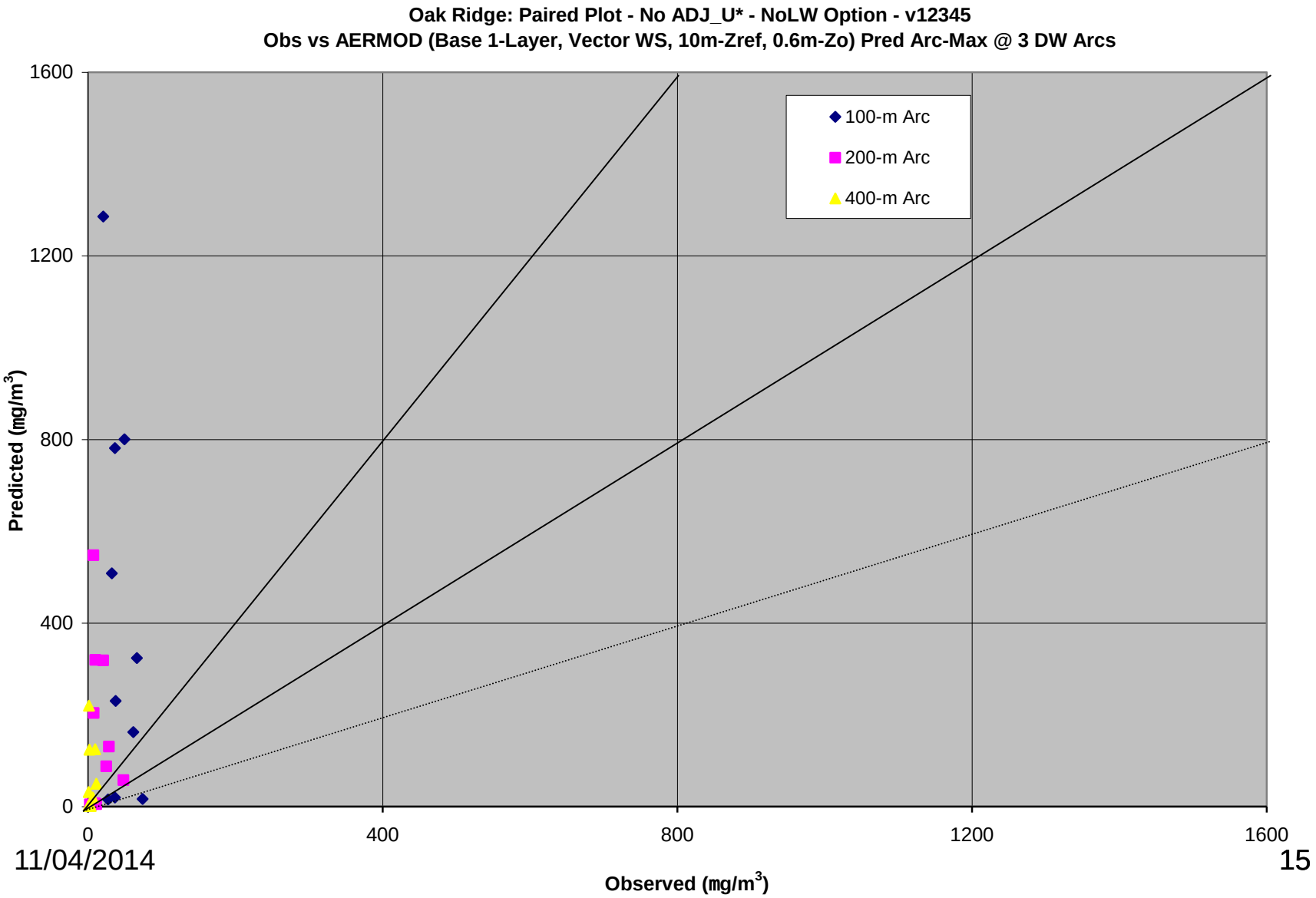
Oak Ridge – NoADJ_U* & NoLW v12345



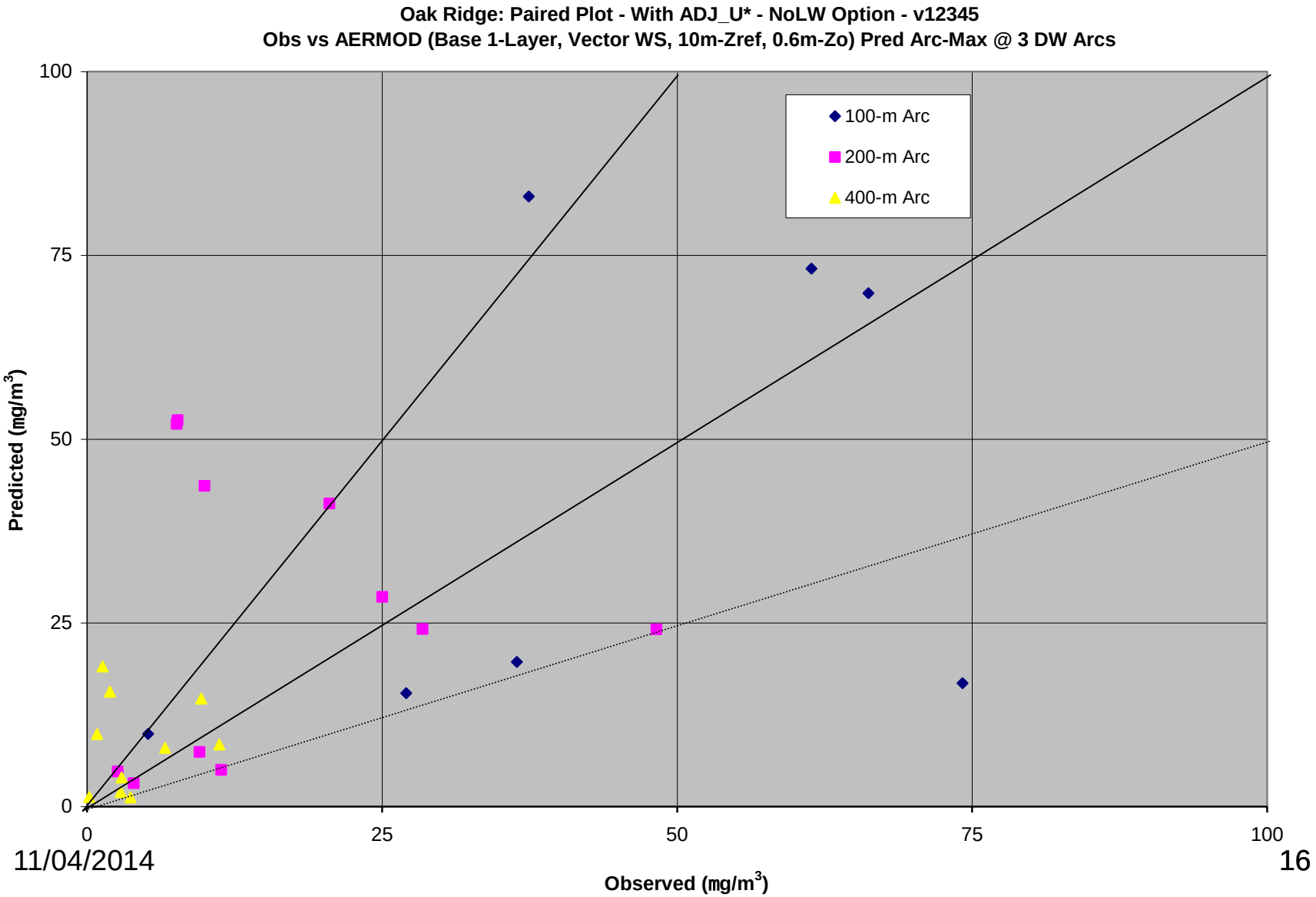
Oak Ridge – ADJ_U* w/NoLW v12345



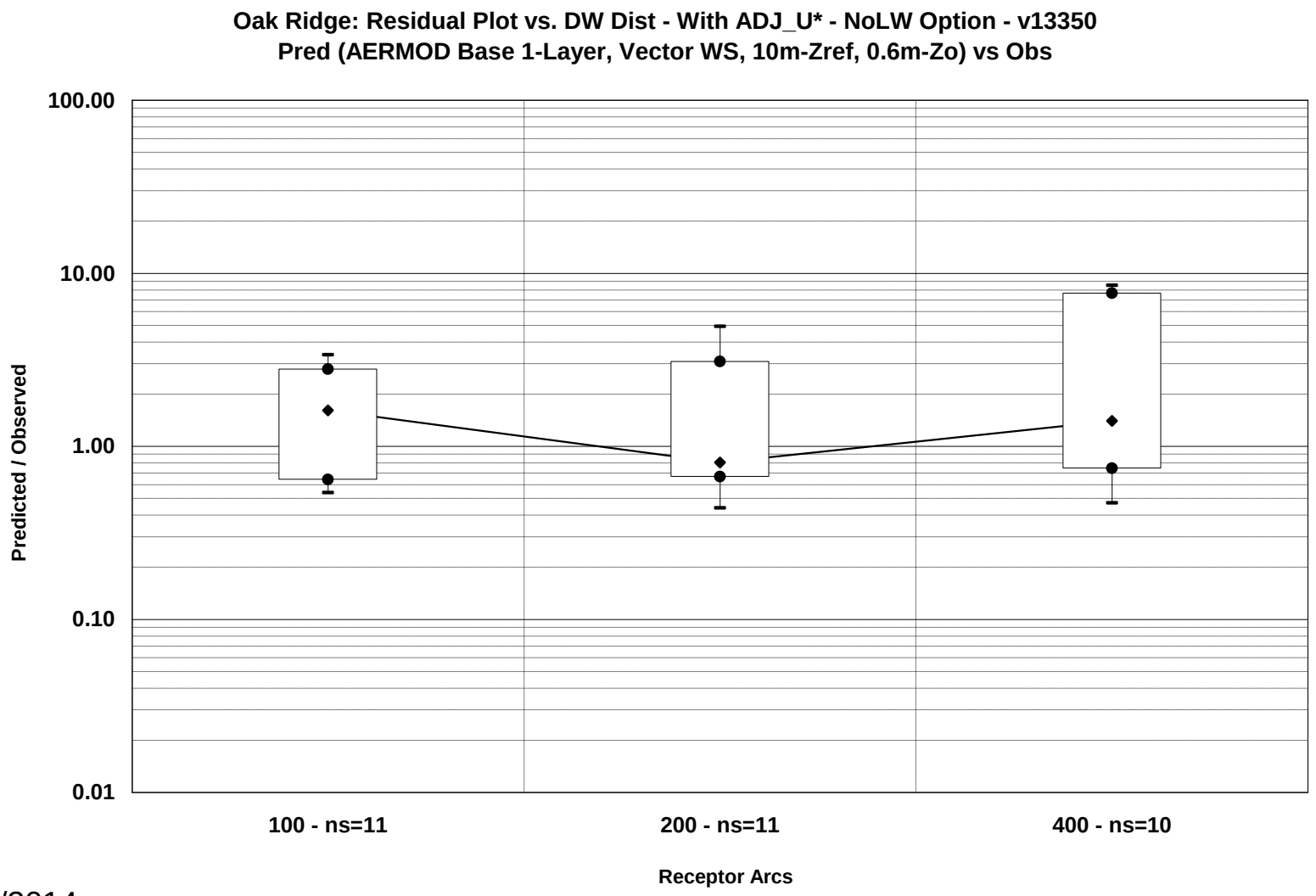
Oak Ridge – ADJ_U* w/NoLW v12345



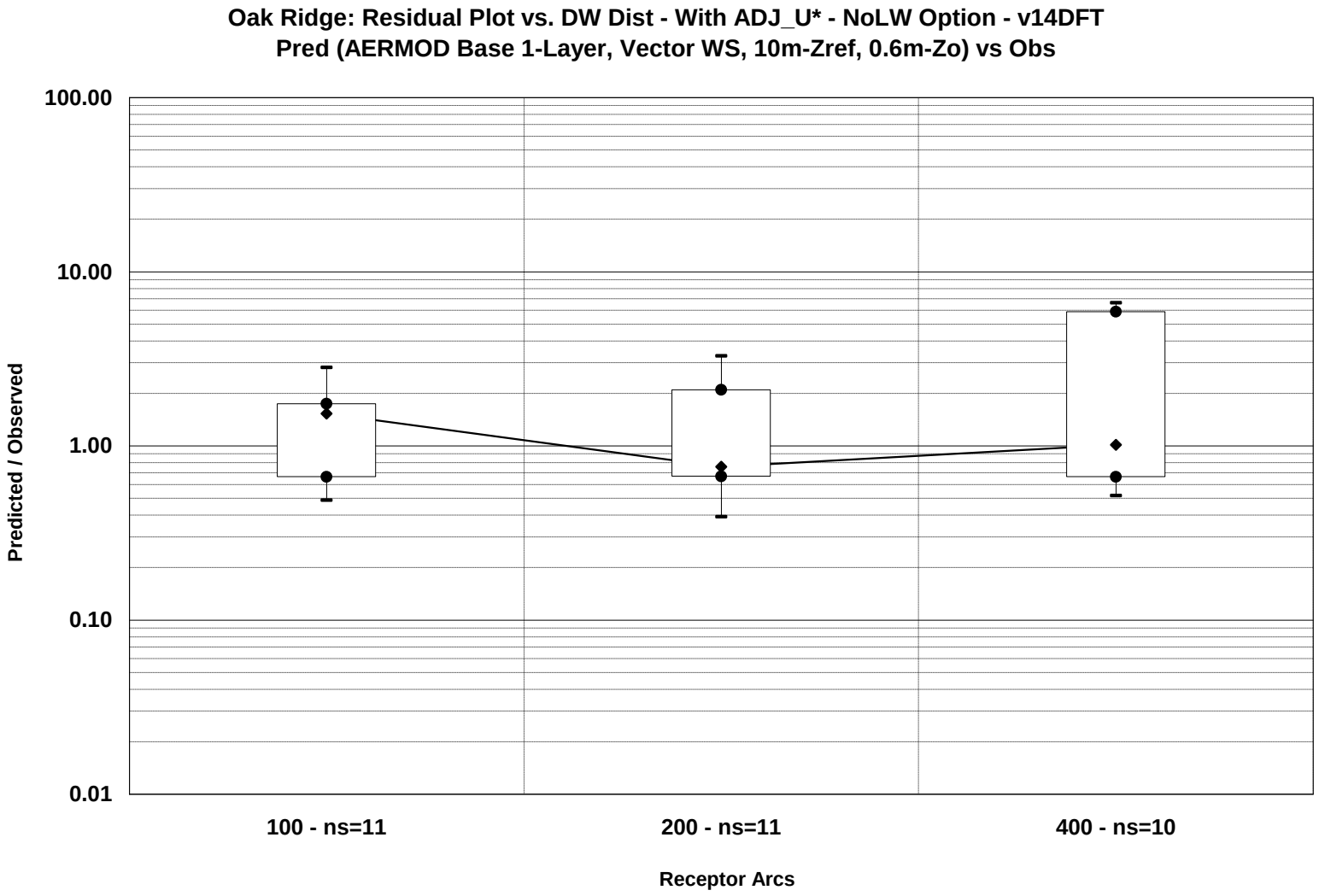
Oak Ridge – ADJ_U* w/NoLW v12345



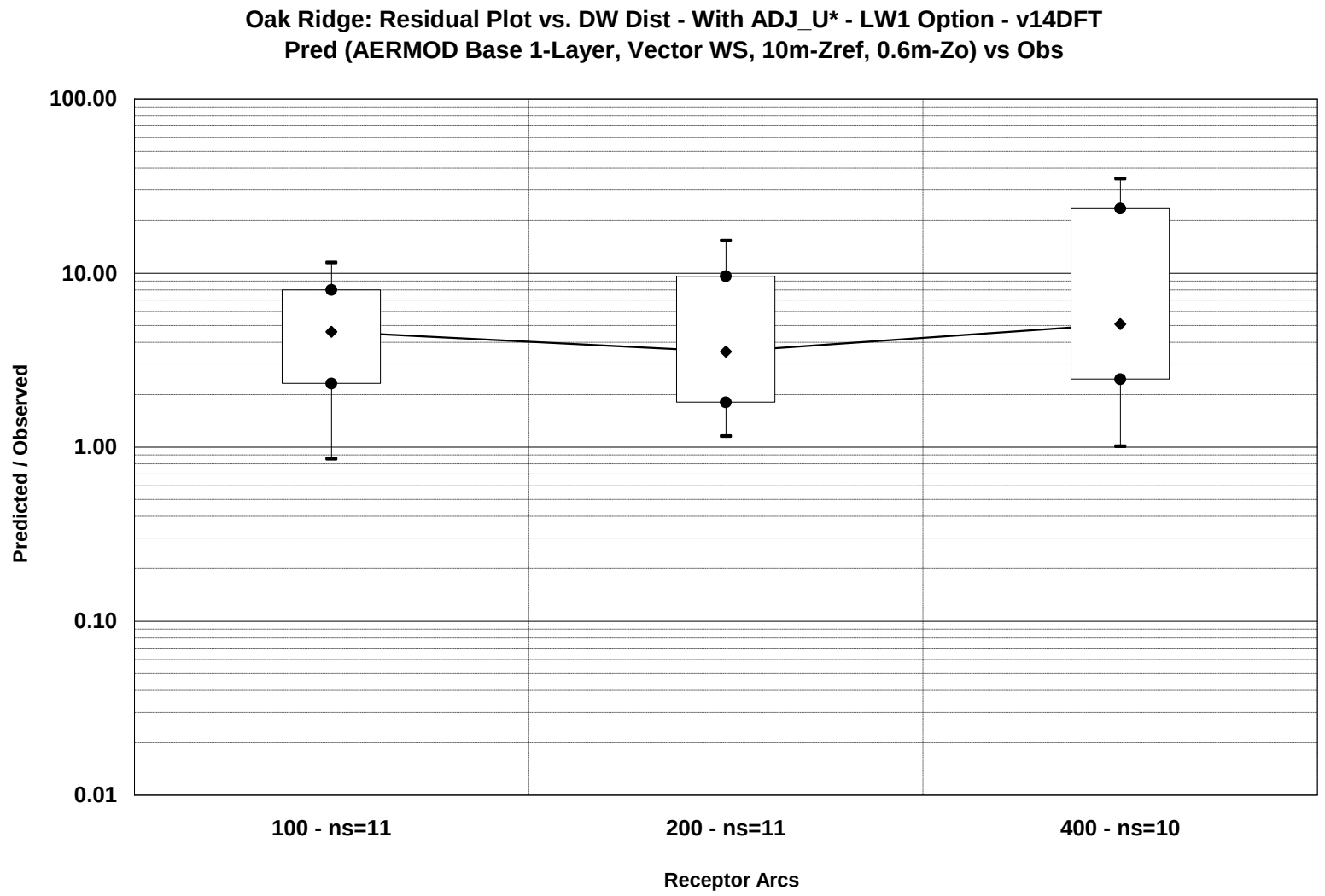
Oak Ridge – ADJ_U* w/NoLW v13350



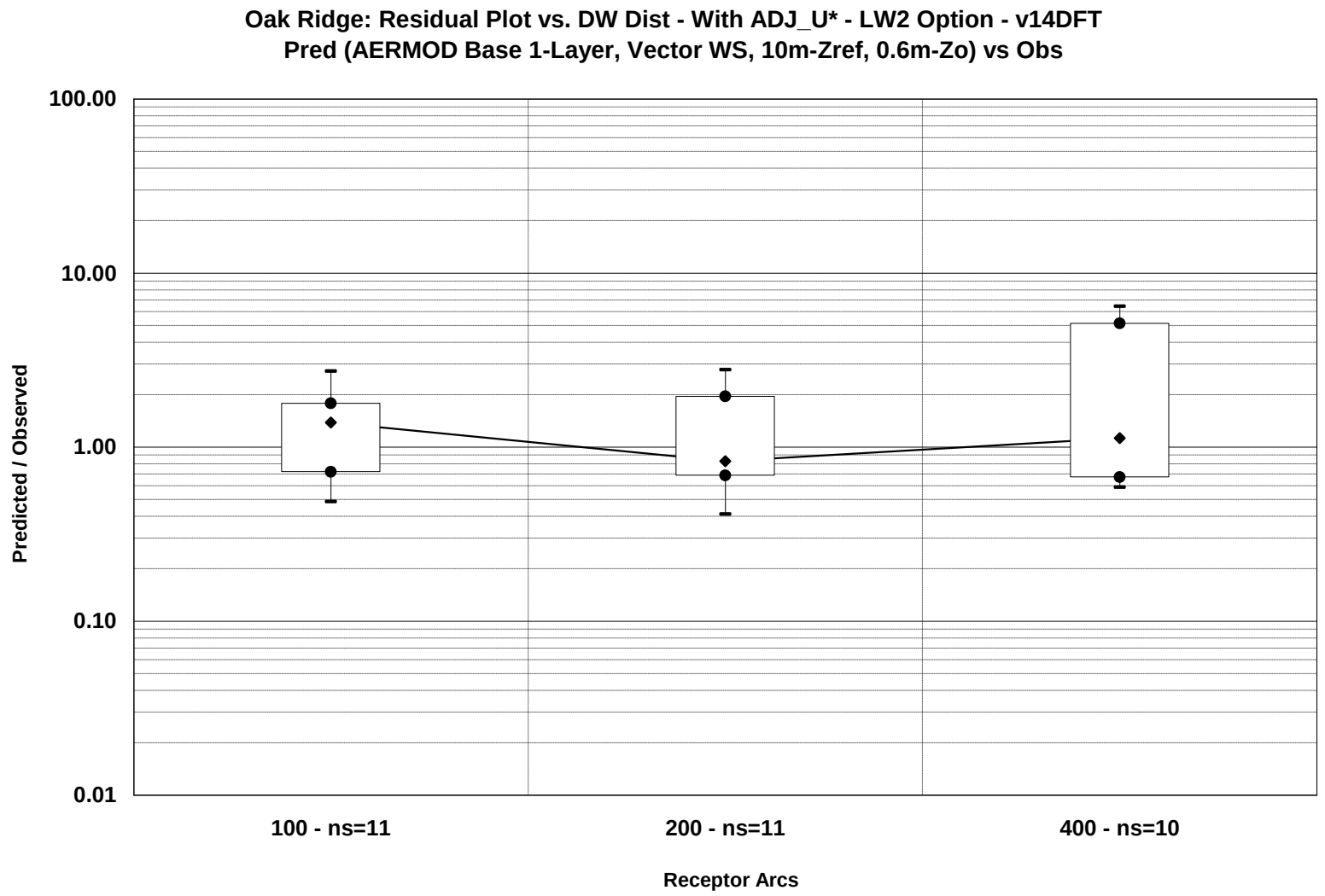
Oak Ridge – ADJ_U* w/NoLW v14DFT



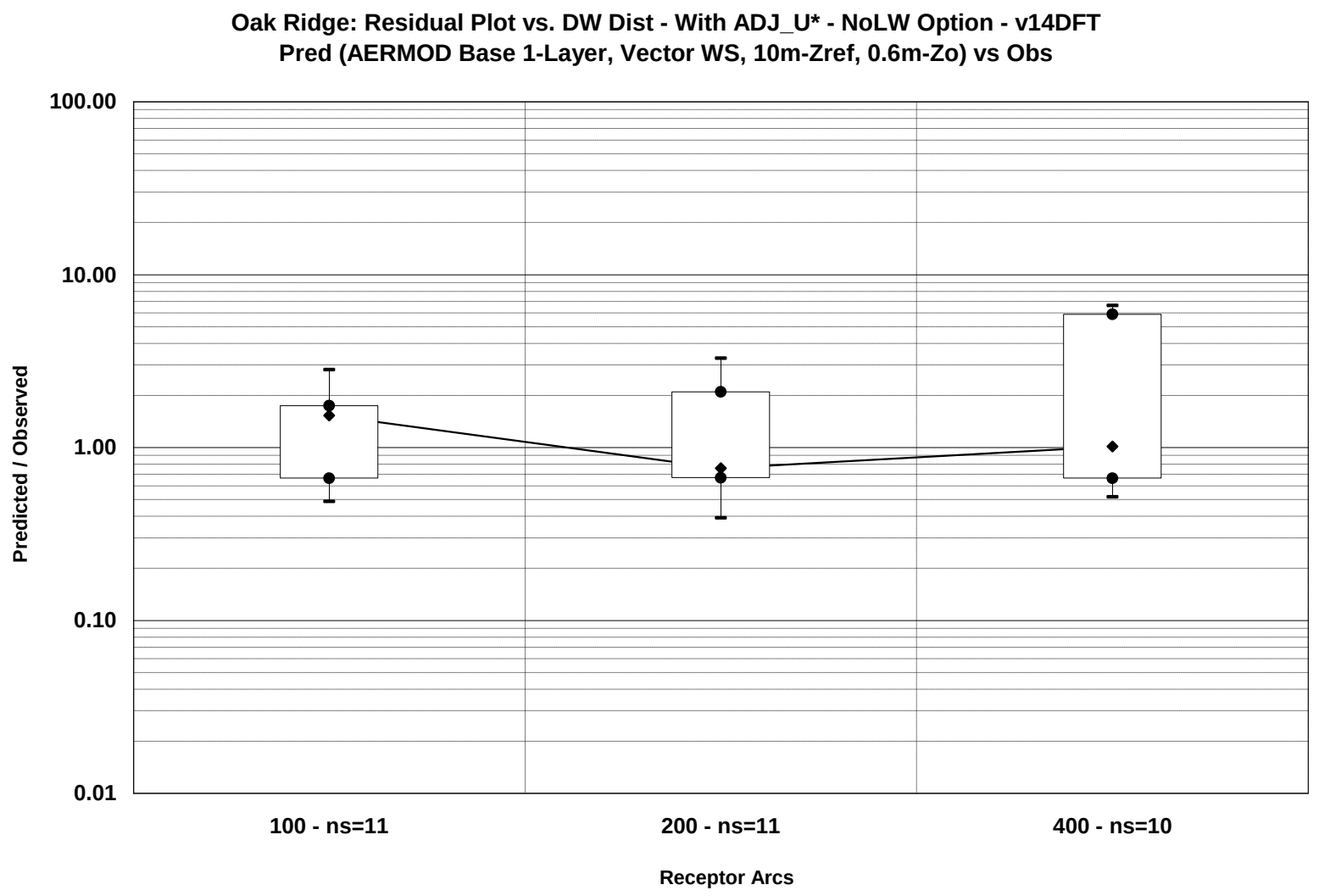
Oak Ridge – ADJ_U* w/LW1 v14DFT



Oak Ridge – ADJ_U* w/LW2 v14DFT



Oak Ridge – ADJ_U* w/NoLW v14DFT



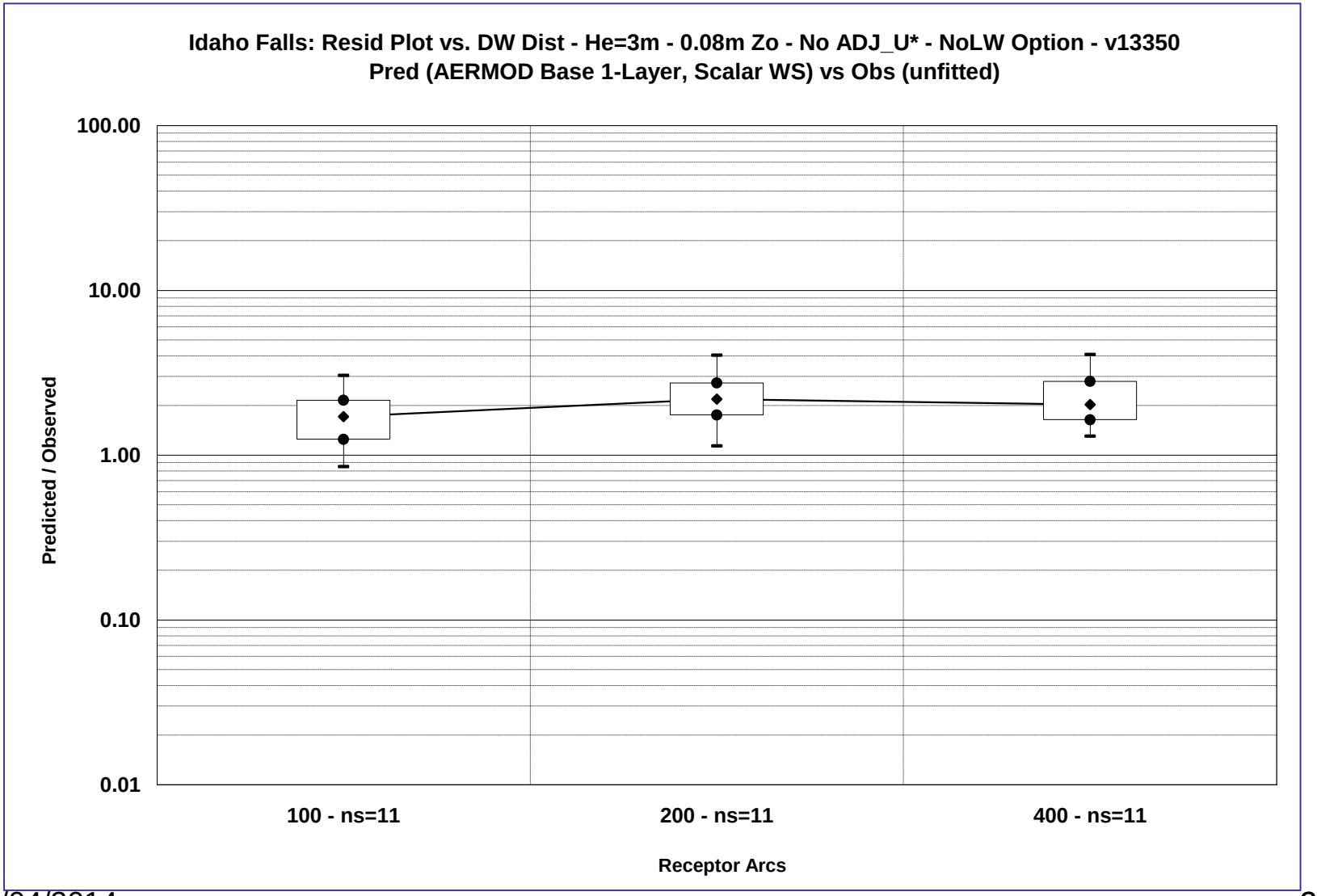
Idaho Falls Study Area

Google earth

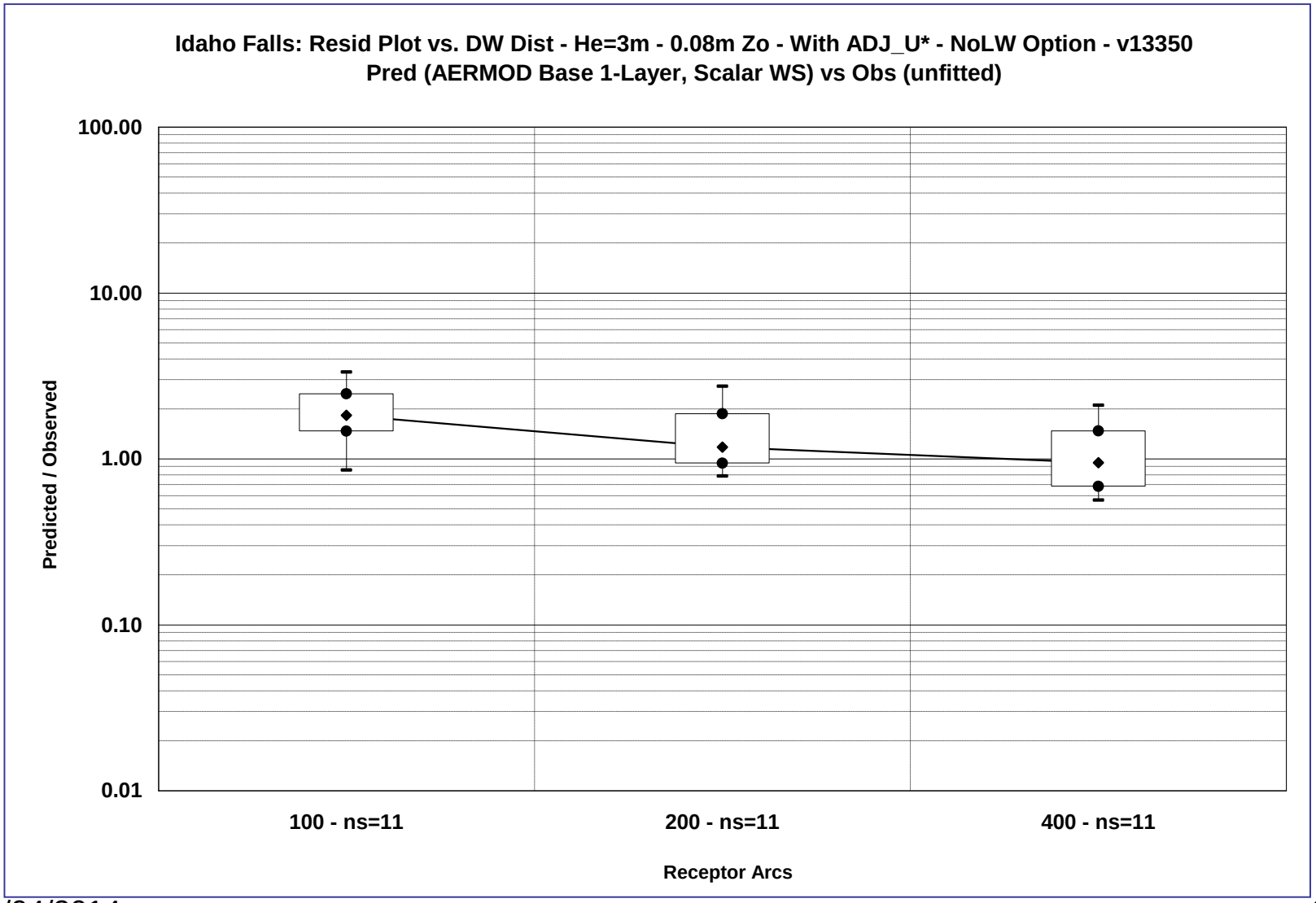
feet 1000

meters 600

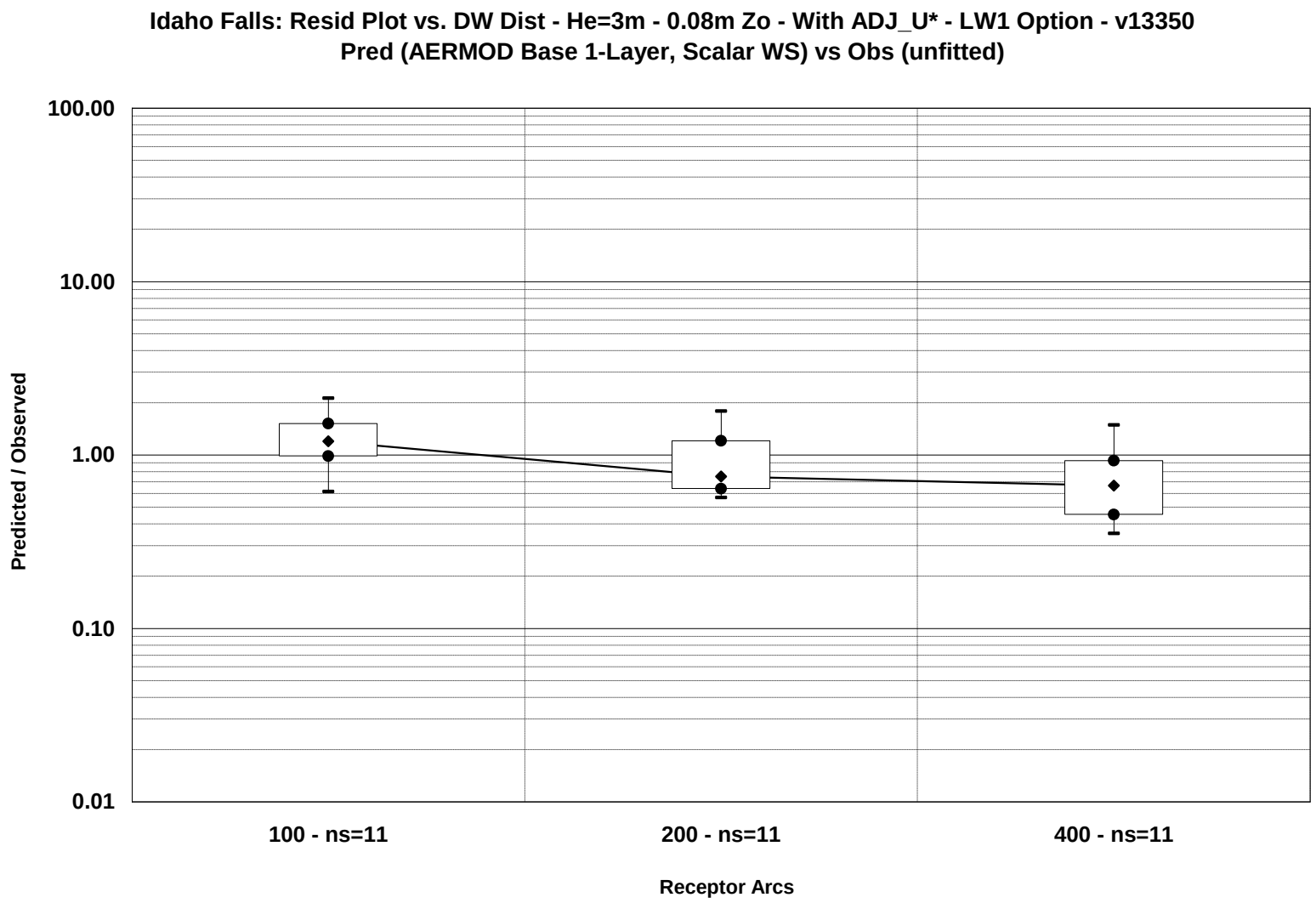
Idaho Falls – NoADJ_U* & NoLW v13350



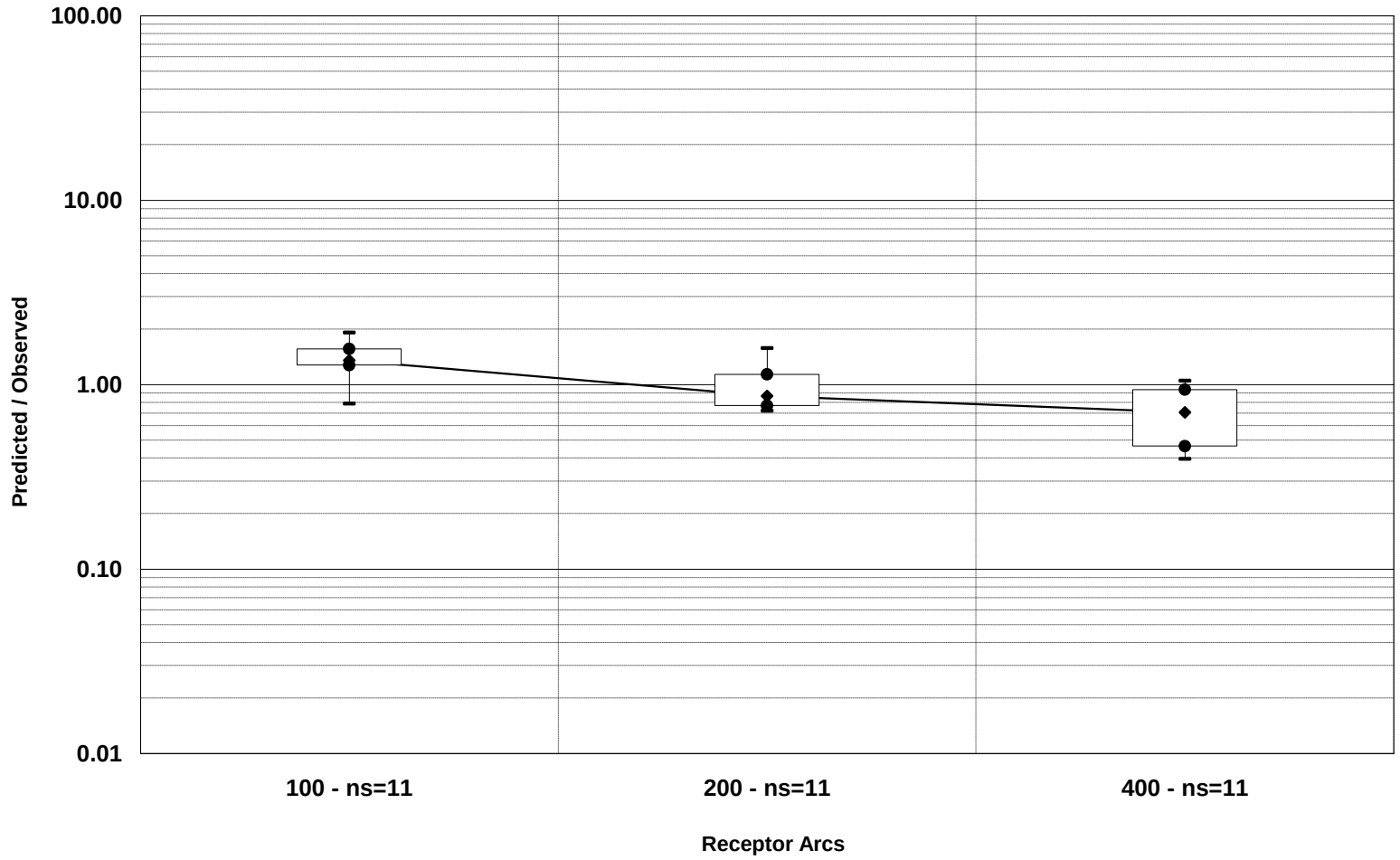
Idaho Falls – ADJ_U* w/NoLW – v13350



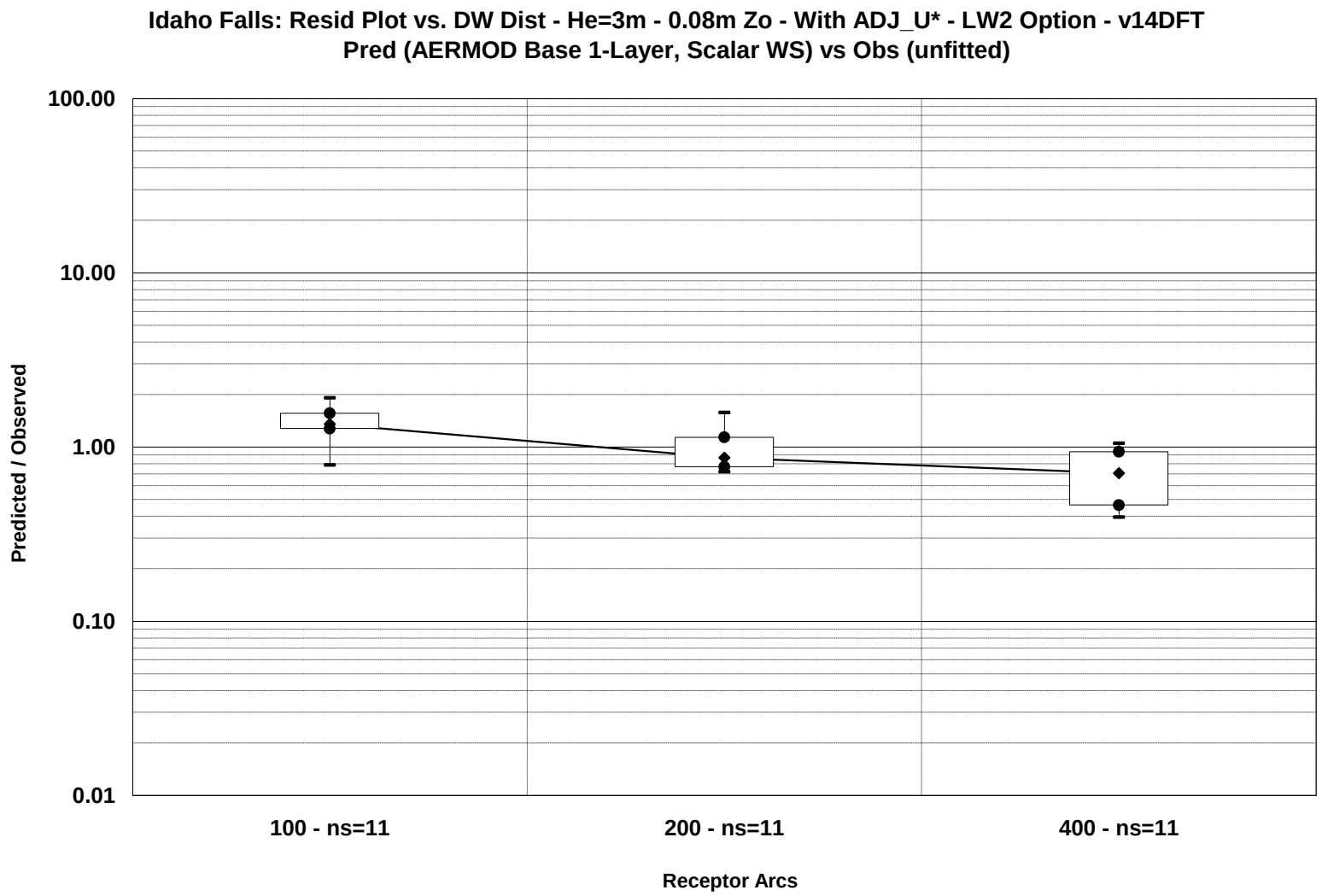
Idaho Falls – ADJ_U* LW1 – v13350



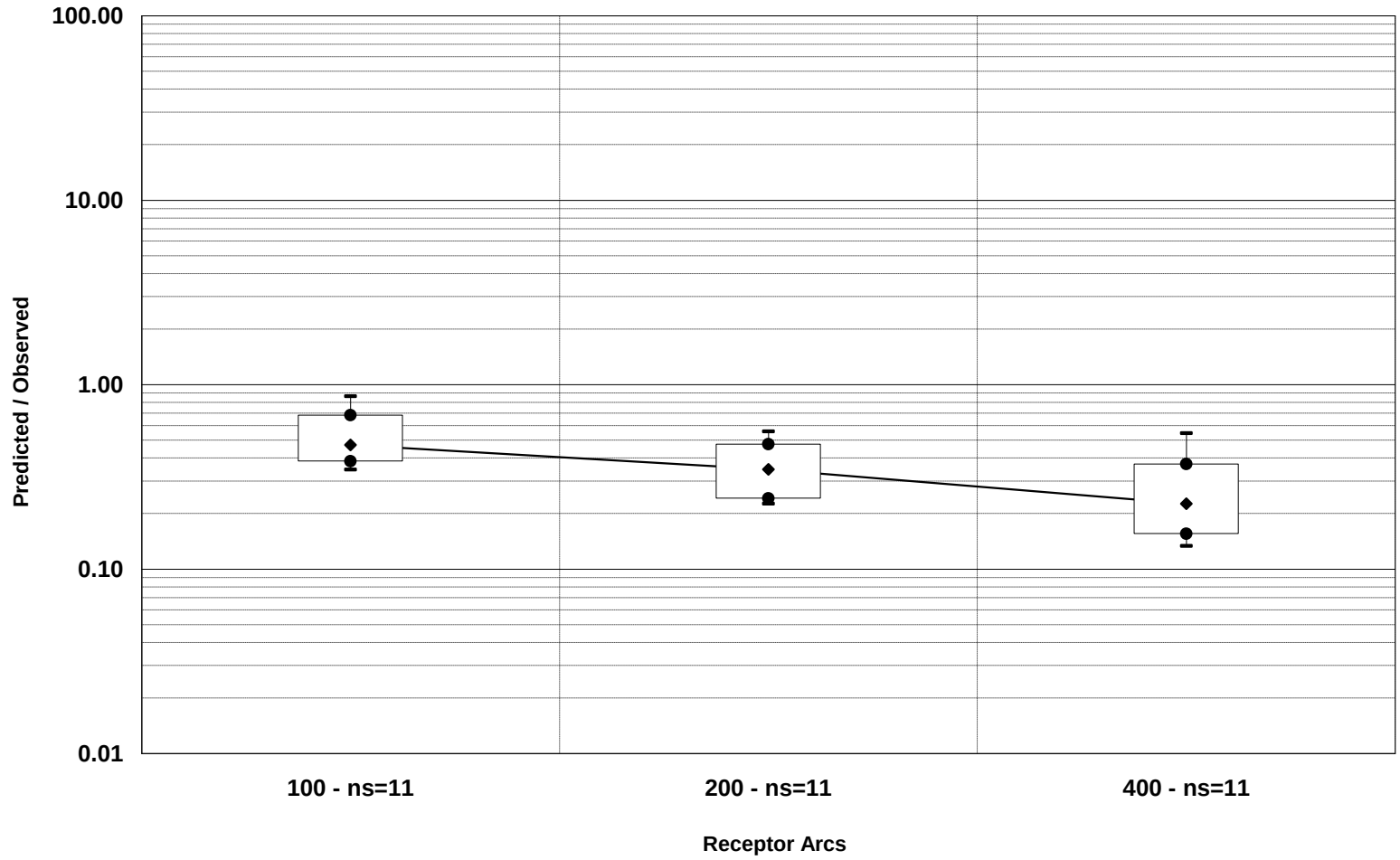
Idaho Falls – ADJ_U* LW2 – v13350



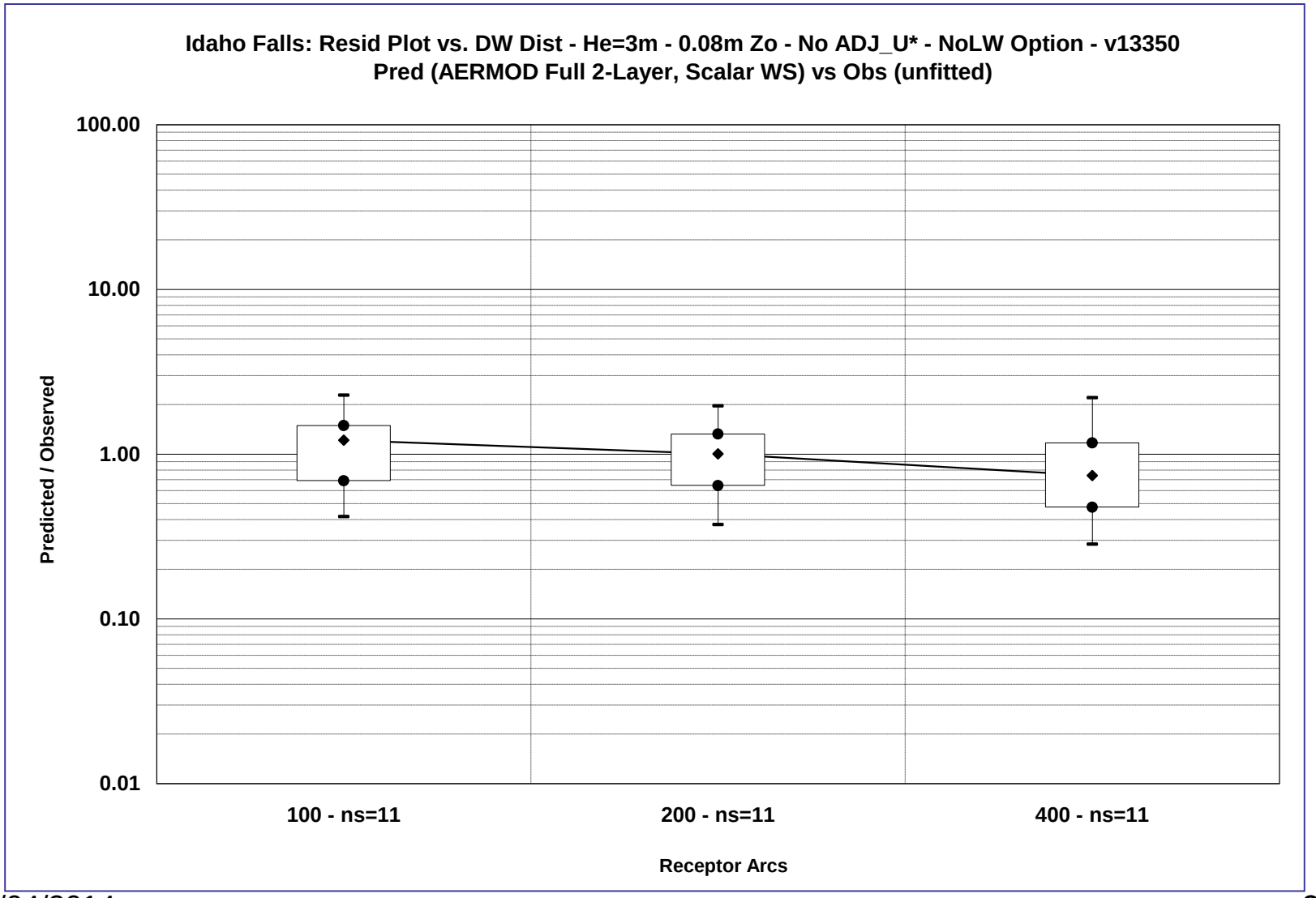
Idaho Falls – ADJ_U* LW2 – v14DFT



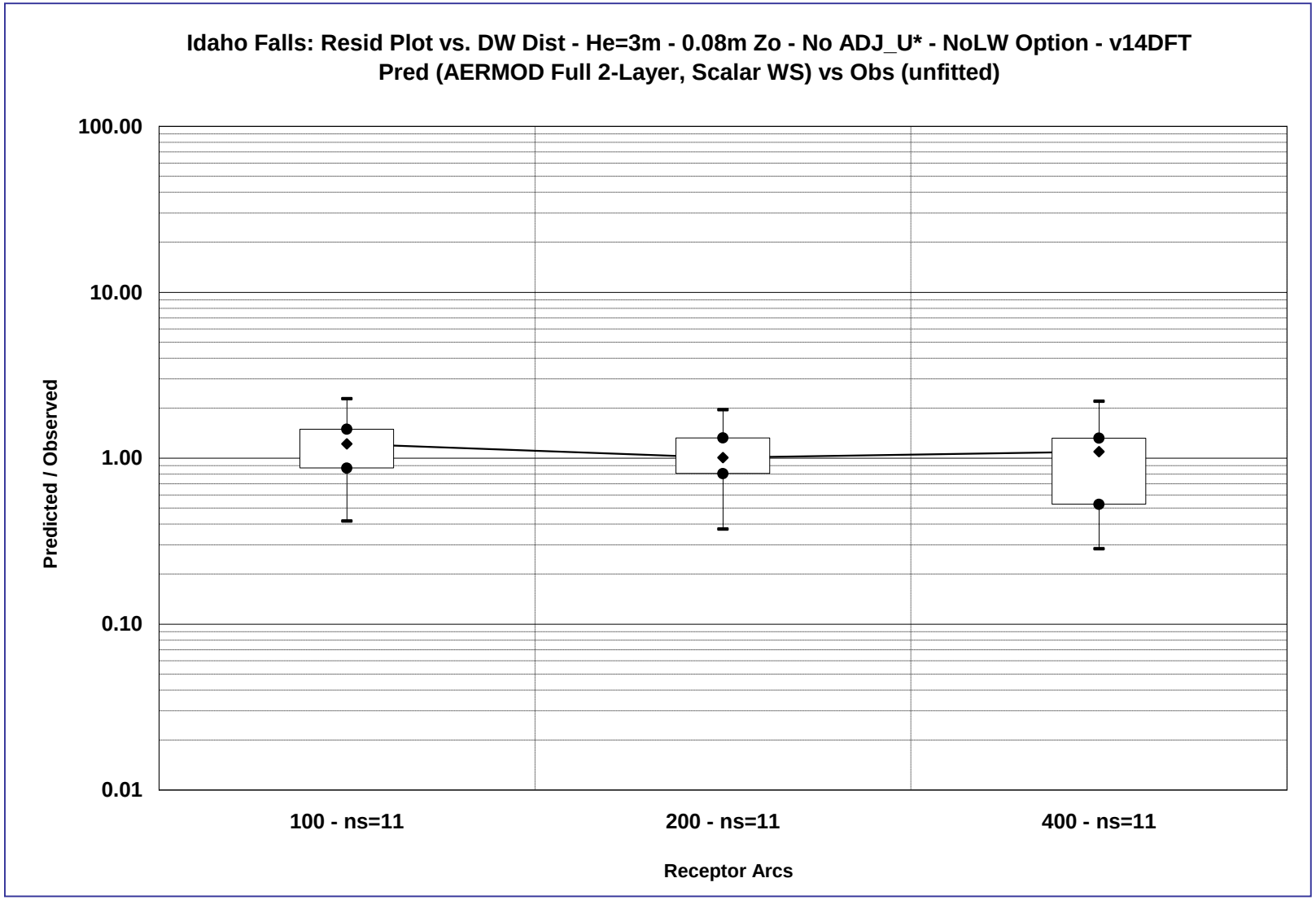
Idaho Falls – ADJ_U* LW2 w/0.5 SVmin



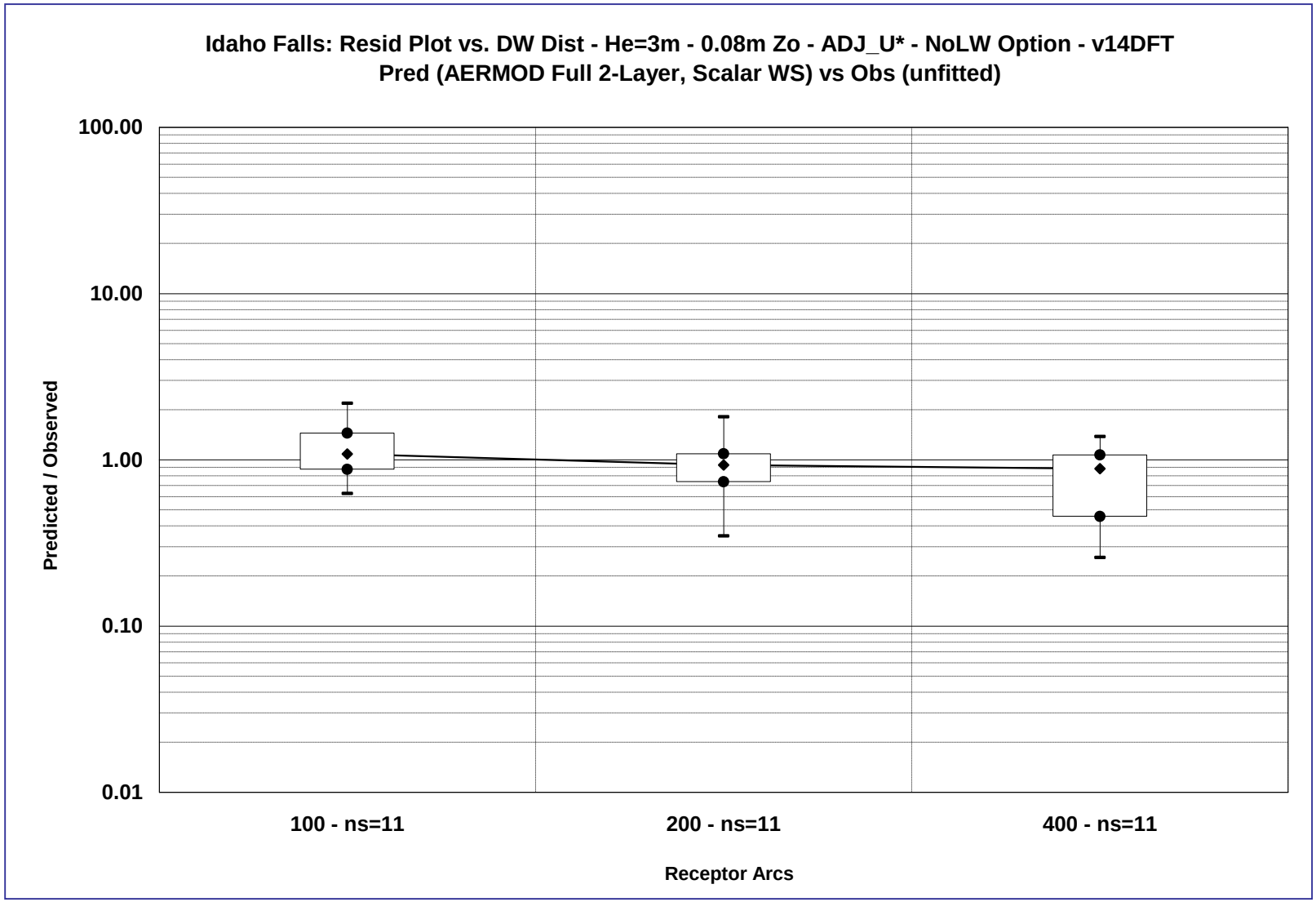
Idaho Falls – NoADJ w/BULKRN v13350



Idaho Falls – NoADJ w/BULKRN v14DFT



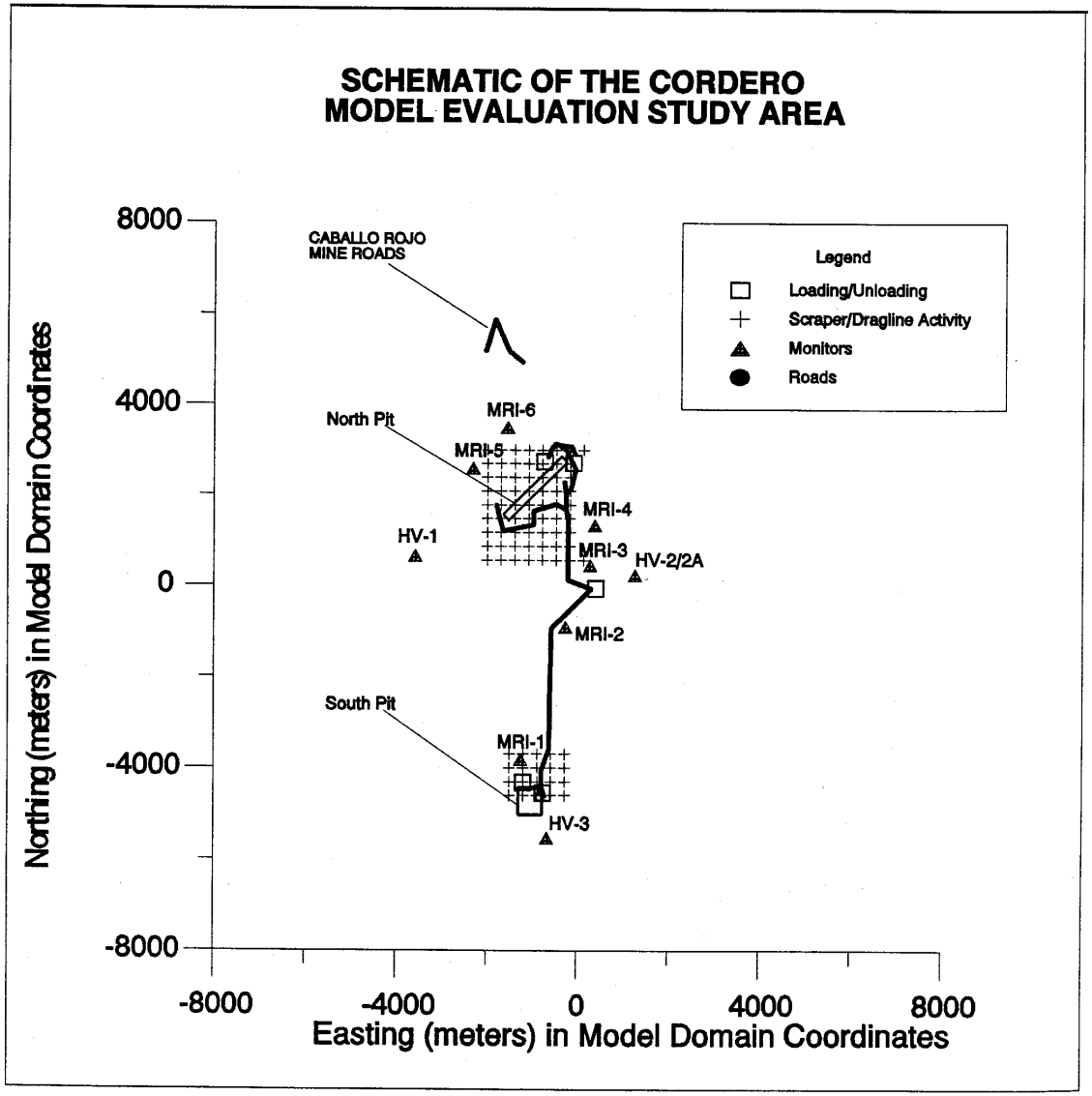
Idaho Falls – Adj_U* w/BULKRN v14DFT



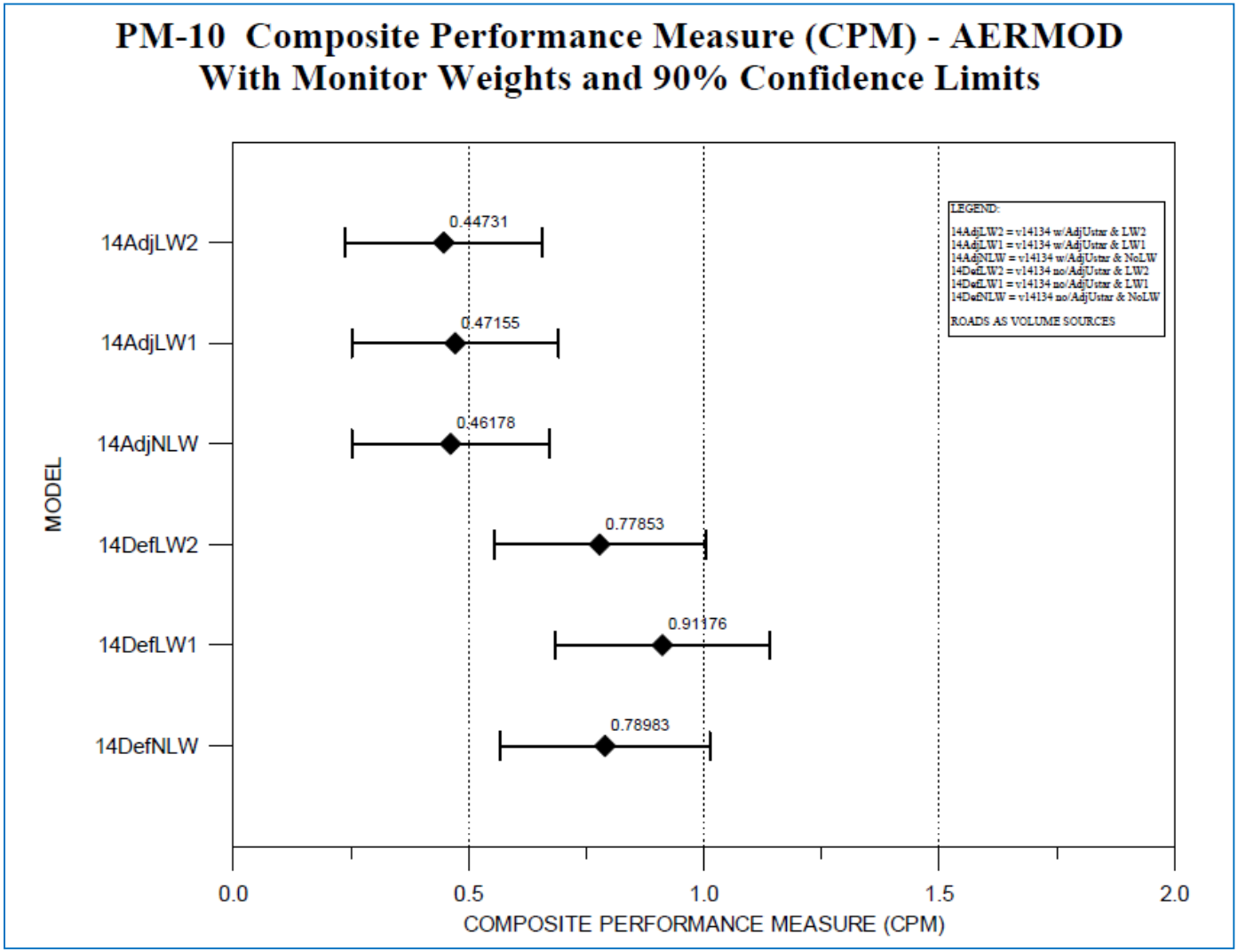
Evaluation of Beta Options

- Surface Coal Mine PM10 Study
  - Cordero Rojo Mine in eastern Wyoming
  - Two-month Field Study in 1993 to evaluate new emission factor and dispersion model options
  - Evaluated 24-hour averages for PM-10 and TSP
  - Majority of emissions (~75%) from roadways
  - Cox-Tikvart protocol for determining the “best performing” model applied to give “confidence intervals” on model performance

Evaluation of Beta Options

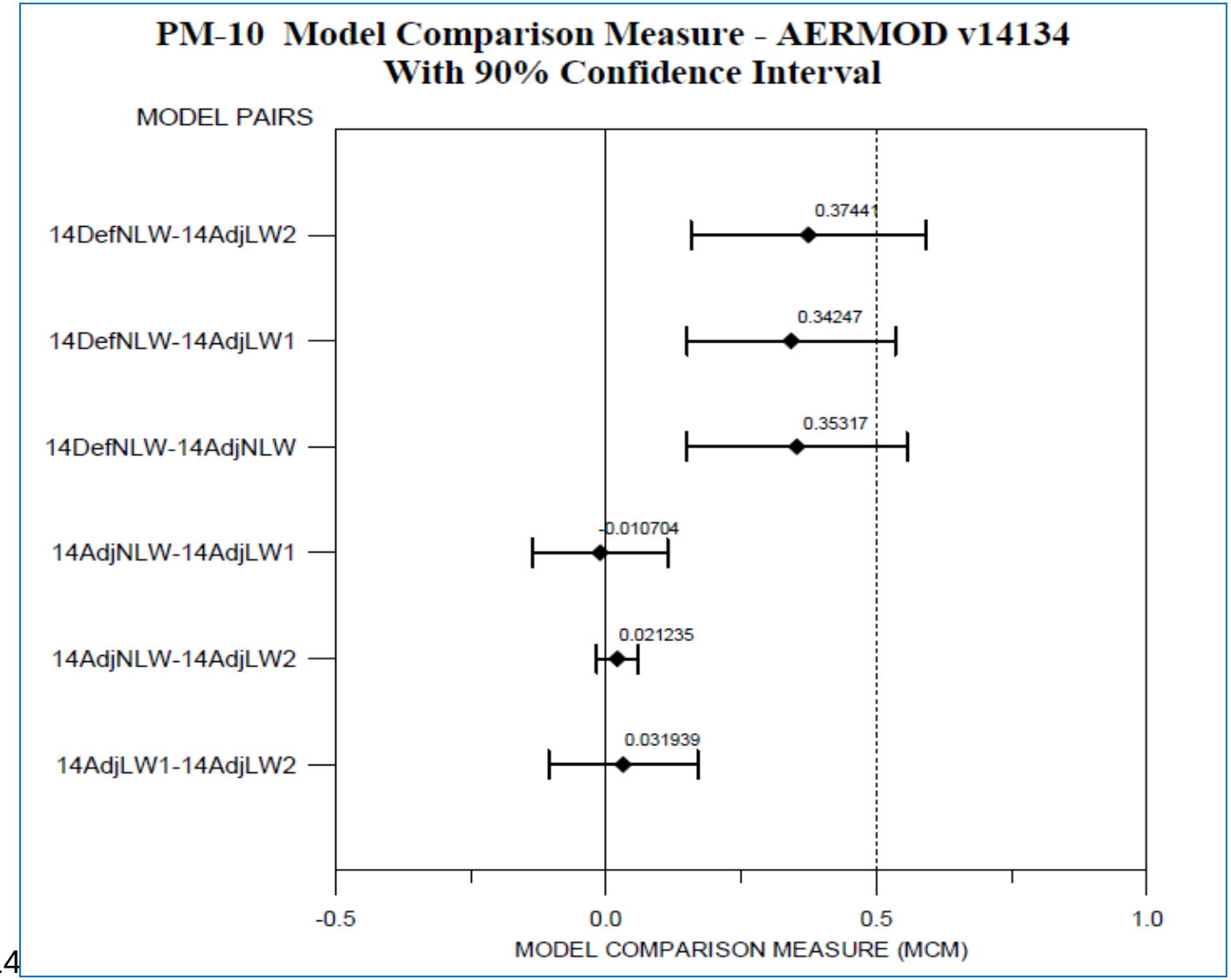


Evaluation of Beta Options



Note: Smaller value of CPM indicates “better” performance

Evaluation of Beta Options



Note: If MCM confidence interval spans zero performance differences are <u>not</u> statistically significant

Future Plans for AERSURFACE

- Release Beta version of AERSURFACE with Effective Roughness Method based on IBL approach:
  - Supports 1992, 2001 and 2006 NLCD data, supplemented by 2001/2006 Impervious and 2001 Canopy data;
  - Based on evaluation results, IBL approach shows better performance vs. IBL estimates than current approach with default 1km radius; however IBL/GFM results suggest that 1km is a reasonable default;
  - Beta version will utilize a pathway/keyword user interface, similar to AERMOD, and will include an option to specify different locations and separate data files for surface roughness vs. Bowen ratio and albedo, as discussed in Section 3.1.2 of AERMOD Implementation Guide;
  - Option to specify “airport” vs. “non-airport” by sector is also included for cases where buildings are located close to tower location.

Future Plans for AERSURFACE

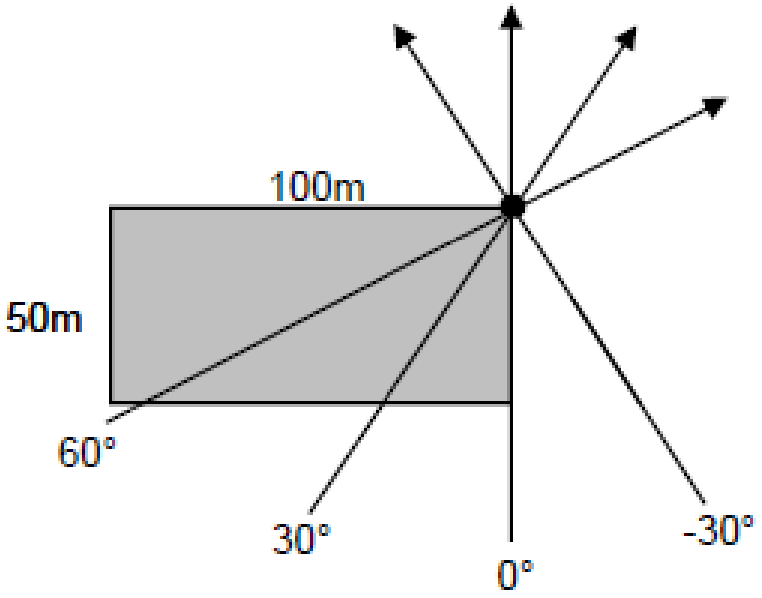
- Release Gust Factor (GF) Tool for use with 1-min ASOS wind data:
  - GF Tool may provide a useful QA check for results based on AERSURFACE, potentially identifying issues with temporal representativeness of NLCD data, misclassified land cover categories, and/or errors in tower location;
  - GF Tool may also serve as an alternative source of surface roughness inputs to AERMET in some cases.

Upper Air Data Substitution

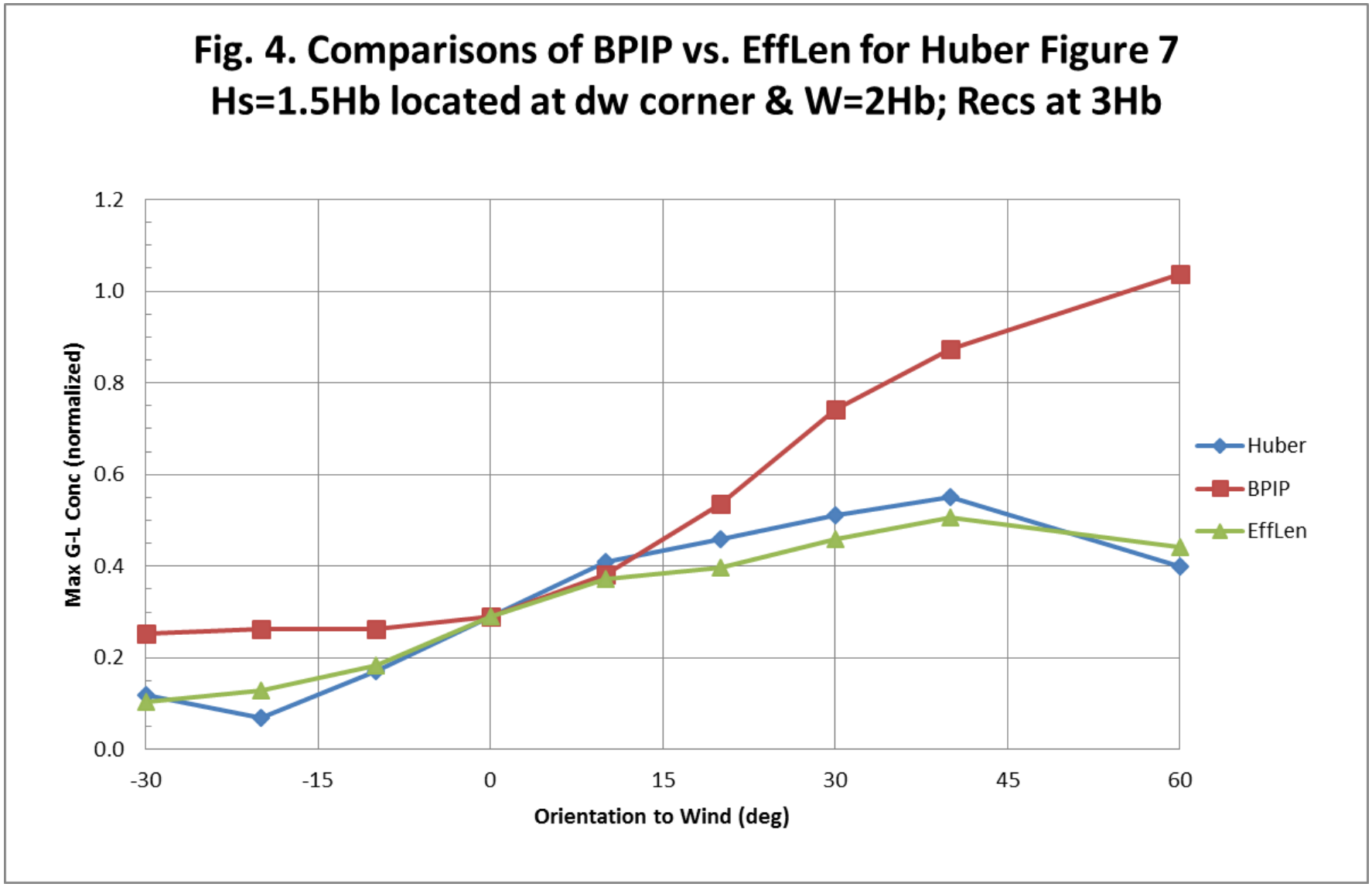
- An UA data substitution tool has been developed to facilitate the use of more than one representative upper air data source (undergoing internal review);
- When UA data is missing, all convective hours for that day will be missing:
  - This may introduce a bias in modeled results, and users may not be aware of how often this occurs;
- Since UA data is typically representative of a large area, multiple UA stations may be adequately representative for a given application;
- The tool “splices” together UA data from a primary station and up to two alternative stations; substituted days are identified in AERMET Stage 1 report file.

Downwash Issue for Elongated Buildings

Fig. 1. Huber Wind Tunnel Study - Case S2 - Source at Downwind Corner of Building (W=2Hb)

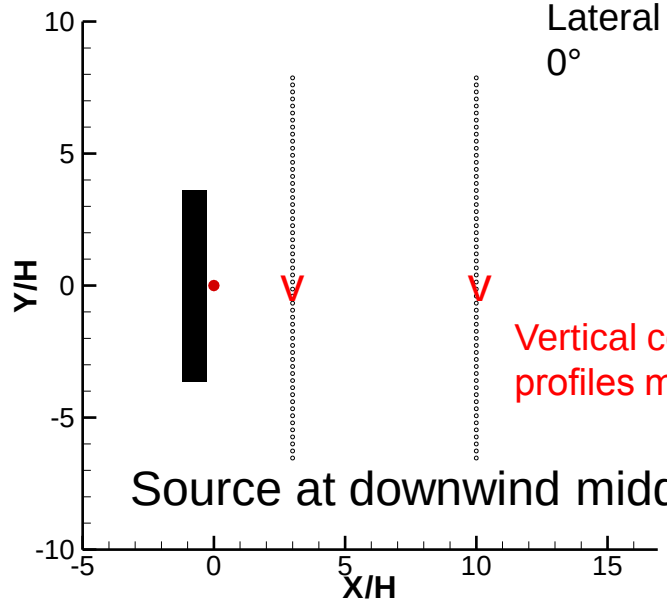


Downwash Issue for Elongated Buildings



Completed & planned measurements
h_s=1.5H

1 x 8 Building



Lateral profiles
0°

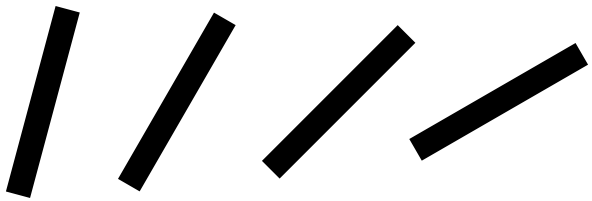
Vertical concentration profiles marked with a ‘v’

Source at downwind middle of building

File names:

BD_1.5H_DM_1x8_0_x=450_z=7

BD_1.5H_DM_1x8_0_x=1500_z=7



15° 30° 45° 60°

File names:

BD_1.5H_DM_1x8_15_x=450_z=7

BD_1.5H_DM_1x8_15_x=1500_z=7

BD_1.5H_DM_1x8_30_x=450_z=7

BD_1.5H_DM_1x8_30_x=1500_z=7

BD_1.5H_DM_1x8_45_x=450_z=7

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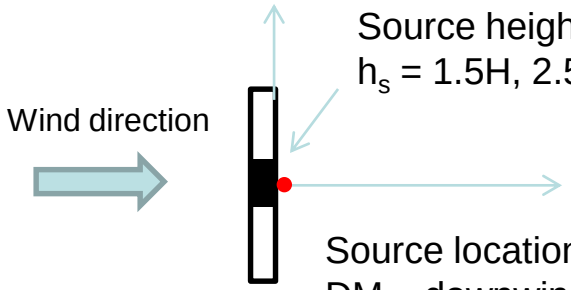
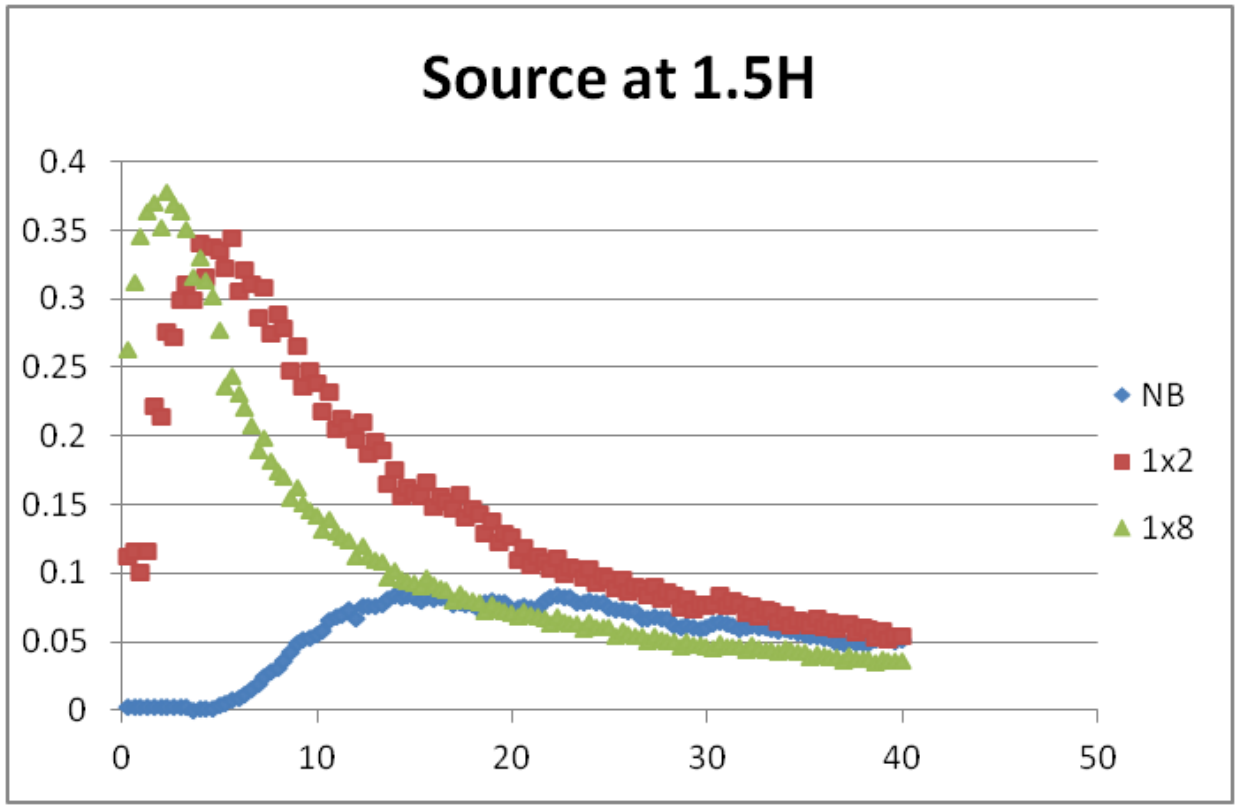
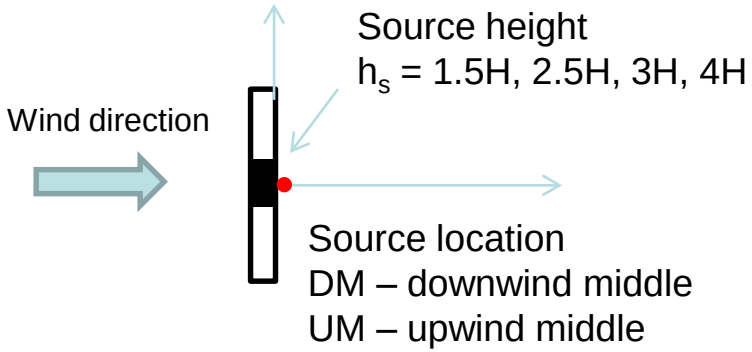
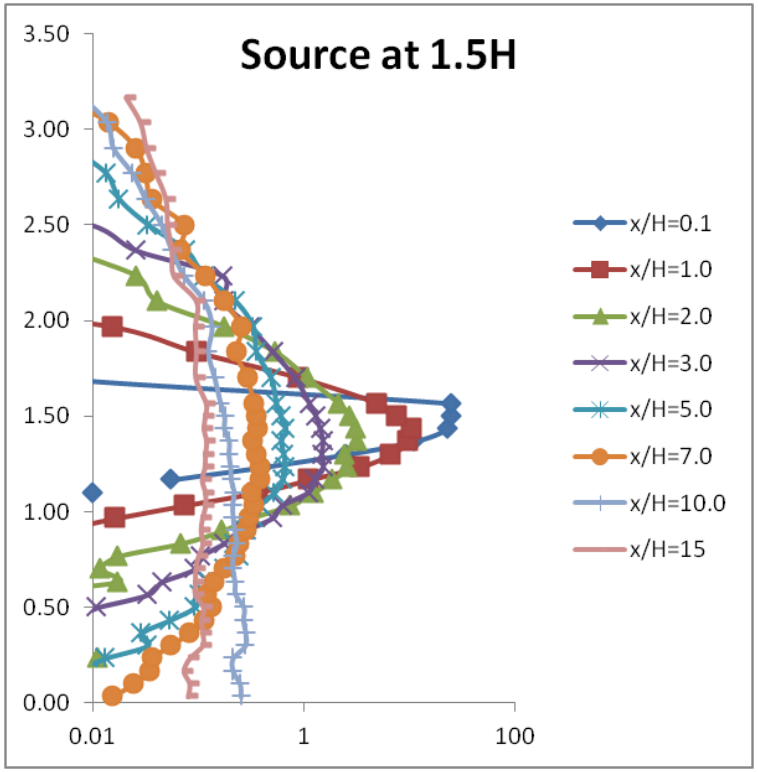


Example results (h_s=1.5H, DM):

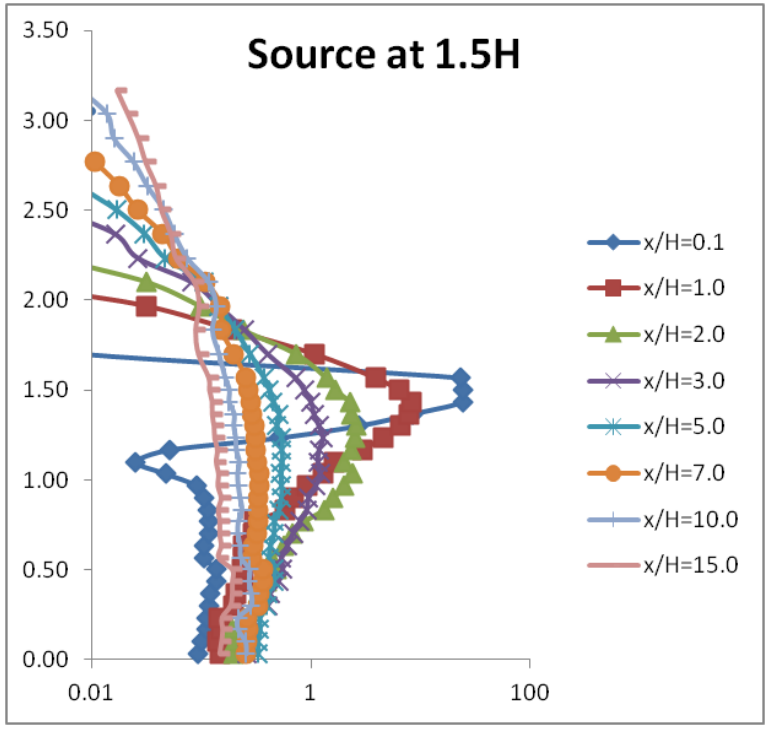




No building

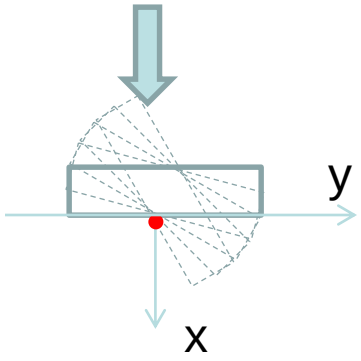


1 x 2 building

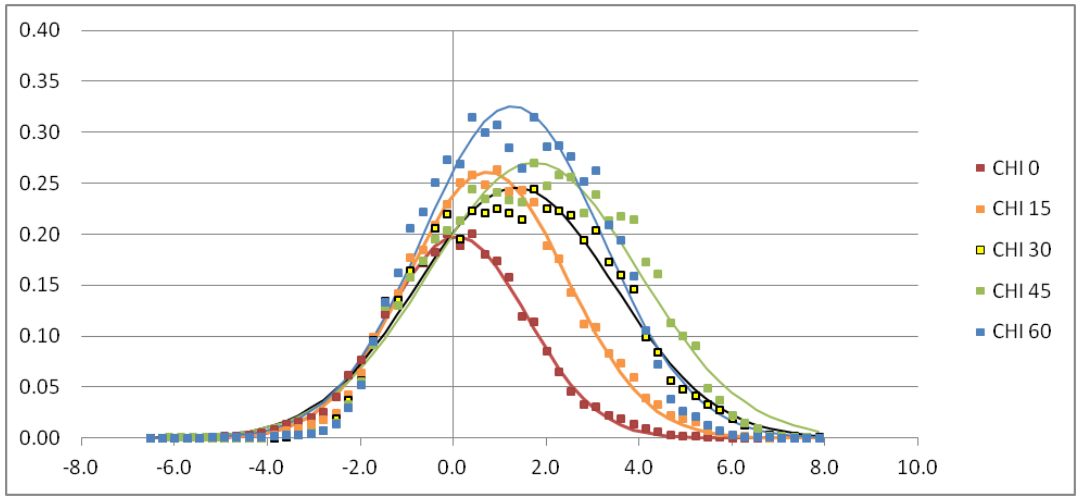


Effect of building rotation on plume width, location and concentration max

Example for:
1 x 4 building,
source @
downwind middle
of building

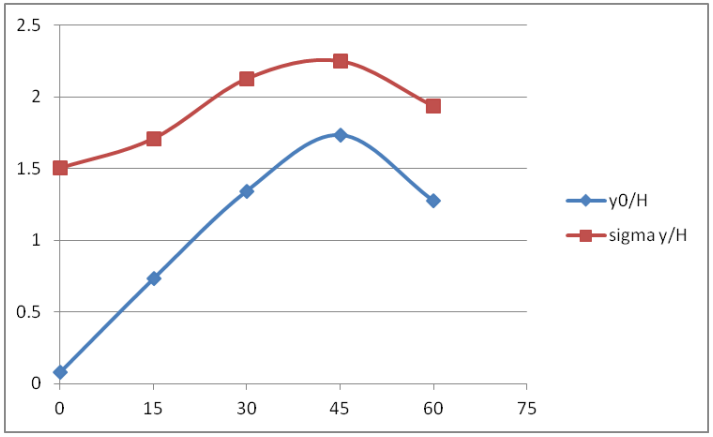


Lateral profiles at x=10H with Gaussian fits



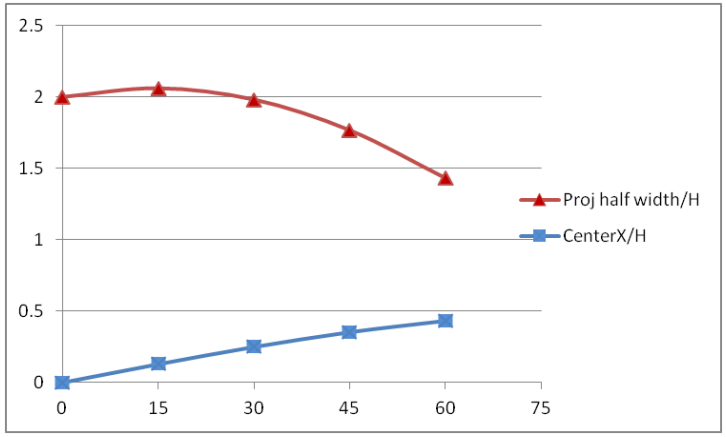
y/H

Location of max & width of plume



wind direction

Building geometry: center & projected width



wind direction

Questions?